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ERP Techniques for Solving Transportation Process in Construction Industry (A case Study of Netherland)

Project Report

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Abstract:

From a work system theoretical point of view, the alignment success factors required to reduce logistics costs when implementing an ERP system are the subject of this study. Associations endeavoring to decrease strategies costs through ERP execution should consider the cycles and exercises engaged with adjusting members, data, innovation, and business processes. This research focused on identifying the factors for ERP success from both the implementation project and user adoption perspectives because there have been few attempts to empirically validate the factors affecting both ERP implementation and user adoption. The relationship between the discovered factors and the redefined ERP's success indicators was then examined. In addition, based on its findings, the study offered suggestions for ERP success. These suggestions showed how to move toward ERP execution to forestall disappointment and what we should do thinking about the meaning of each component to a specific ward variable. Engineering and construction companies considering the implementation or upgrade of ERP systems may benefit from the information provided by these recommendations. EPR frameworks ought to improve the probability that organizations will expand their business esteem by exploiting this data to decrease the critical dangers related with executing ERP.

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Smart ERP Techniques in for Solving Vehicle Routing Problems in Construction Industry

1-Introduction

The construction industry is known to be one of the biggest industries in our world and it has been that way for the past few centuries. Financial analysts estimate the output of global construction industry in 2022 to be worth almost 13 trillion US Dollars (GLOBALDATA, 2022). Further, it employs 7% of the global workforce. Further, the construction industry is one of the very few industries in this world that employs a large number of skilled and unskilled people alike. Therefore, it benefits not only the educated, degree-holding classes of a country but also the less privileged classes that have to rely on physical and manual labor to earn their living. All of this serves to highlight how crucial the construction industry is to the global economy and particularly in developing countries, where the literacy rate is often quite low and unemployment is rampant.

Due to its massive importance all over the globe, researchers and analysts are always on the lookout for ways to optimize the processes involved in the process of construction. This can enable construction companies to increase their productivity and

efficiency as well as reduce their wastage. This is also partially due to the fact that construction is a very wide term that encompasses numerous processes and, as mentioned previously, involves various people from different educational backgrounds working together. For example, for the design of a simple building, architects, structural engineers, geotechnical engineers, contractors and laborers all have to work together. In a more complex project of a bigger scale, even more stakeholders become involved such as the government, engineering consultants, bidders, etc.

When so many stakeholders are involved and multiple processes are being carried out, it is extremely essential that the entire project is streamlined. This helps ensure that all tasks that make up the aforementioned project are completed on time and within budget. Negligence in this matter leads to increase in costs as well as wastage of resources.

Unfortunately, the construction industry remains outdated and ancient in regards to its practices all over the world, particularly in developing countries. Moreover, it is very difficult to implement changes or introduce new systems in any construction industry anywhere in the world. This is largely because many stakeholders in the industry—such as laborers, masons, painters, plumbers, etc.—are often illiterate and, therefore, unable to deal with changes in how they do their jobs. They are usually unable to adapt to new methods as their current methods are all they know and, hence, their only way to earn their livelihood. Hence,

they often turn out to be very stubborn when management tries to implement any changes to ensure streamlining and, as a result, they tend to resist those changes.

2-Literature Review

Enterprise Resource Planning (ERP) is an information system that is designed specifically to integrate and optimize the processes of a business and the transactions in a corporation (Moon, 2007). ERP is intended to streamline the process and various sectors of a business, often in a central database, which makes management and supervision of all those processes easier.

ERP has several components, since it encompasses all sectors or divisions of a business. It goes without saying that these components will differ across different organizations, based on their scope and size. However, some typical components exist in all businesses. They are:

1. Supply Chain
2. Inventory Management
3. Finance
4. Human Resources
5. Time and Projects
6. Customer Relationship Management (CRM) & Sales

Figure 1: Typical component of an ERP system

Various studies have been carried out that have centered on ERP techniques. All studies can be categorized into the following themes:

1. Implementation of ERP
2. Optimization of ERP
3. Management through ERP
4. The ERP software
5. ERP for supply chain management
6. Case studies

In a broader context, ERP techniques can be applied on any and all businesses. This is because ERP is a very vast concept that can, in theory, be integrated with any organization, no matter the sector it belongs to. Many studies tend to point out the implementation of ERP techniques or software within an organization is a process that happens over time, rather than

being a single event (Kennerly & Neely, 2001). This is because the implementation of ERP within a business requires a significant amount of resources and personnel. More importantly, it requires workers to change the way they do their jobs, which can often prove to be difficult and cause friction between employees and management.

However, studies also point towards the fact that, when applied properly, ERP systems deliver huge benefits to all stakeholders in a business (Matolcsya, Booth, & Wieder, 2005). Owners, investors, managers and even employees benefit from the results as business operations run more smoothly and profits are increased.

In the context of this study, the implementation of ERP techniques on construction and transportation businesses must be studied to assess its feasibility. There exist many case studies and research articles focused on this niche, all of which point towards the fact that is a great idea with multiple advantages to all stakeholders.

(Karimi, 2017) analyzed the impact of ERP techniques on the performance on transport industry in Kenya. They concluded that ERP techniques had an overall positive impact on the transportation industry. They also pointed to the fact that ERP techniques were directly affected by a multitude of factors such as communication, training and management support.

(Voordijk, Leuven, & Laan, 2003) conducted an in-depth analysis of Enterprise Resource Planning systems implementation in a large-

scale construction firm based in the Netherlands. They were motivated by the fact that, in the Netherlands, many large construction firms attempted, at one point of the other, to implement ERP systems for better streamlining and increased efficiency. However, most of them experiences failures. Hence, using one such construction firm as an example, they sought to find out what factors influence the success of ERP systems in construction firms. They selected a large scale construction firm which had multiple sectors such as construction, infrastructure, consultancy and engineering and, lastly, trade and industry. Basically, this firm was operating in the Dutch construction industry in many different ways, which made it a perfect candidate for this study.

This company—the real name of which had not been disclosed in the study—implemented different types and brands of ERP software in different divisions. Comparative analysis was carried out of these systems with respect to a select few factors such as IT strategy and business strategy, implementation method, organizational change, etc. Data was collected from managers and employees in the form of interviews, observations and ERP related documents.

After a thorough analysis of the data acquired, the researchers reached quite a few conclusions that can serve as a lesson for all construction firms around the world. First and foremost, they concluded that ERP systems play a positive role within construction firms if they are used for streamlining of inter-

organizational primary processes. Basically, ERP systems can be used to streamline and centralize all the different processes happening within a construction company including, but not limited to, site work (i.e. construction), office work (i.e. financial documentation, release of funds and resources, correspondence with clients, etc.) and transportation.

Further, they also concluded that installation and implementation of ERP systems does not necessarily mean that a company has to spend a large amount of financial capital to upgrade its IT resources. On the contrary, ERP systems and softwares can be implemented on what is referred to as an AS-IS basis i.e. they can be installed on the firm's existing IT system. In fact, they recommended this strategy for small-scale firms or companies that are just starting out.

On the other hand, for large-scale companies which have various divisions and are involved in multiple sectors of the construction industry (such as the one discussed in the study), they recommended that the IT services be upgraded so that mangers can utilize the full potential of ERP systems and avail maximum benefits from it.

This study also highlighted that many other construction firms in Netherlands have attempted to integrate ERP systems in their framework but, more often than not, they have been met with failures and decrease in efficiency and employee satisfaction. Using their analysis, they were able to put forth a few probable

reasons for this. The first and foremost of which was the fact that ERP systems, when newly implemented, need constant monitoring by managers. Further, employees also need training in order to familiarize themselves with the new system and new methods of doing their everyday tasks. If care is not taken in this regard, employees will not feel at ease while using the new system and may revert back to their original ways of doing their jobs.

The above highlighted study further reiterates this important fact: ERP techniques are only useful and advantageous when implemented properly. Otherwise, they serve to do more harm than good. This is a key point that organization owners and management must remember when they decide to integrate an ERP system in their firm. If not implemented properly, this endeavor might cause businesses to suffer huge losses.

2.1-Importance of Transportation in Construction Industry

This study deals with the implementation of ERP techniques in the transportation sector of the construction industry. This begs the question: is transportation really that big of a component in the global construction industry? Does it have a big enough stake in the entire process to warrant implementation of a system as sophisticated and resource-consuming as ERP?

As mentioned in the previous sections, transportation is actually required at various stages in the construction project, which

increases its importance. Further, delays are unfortunately very commonplace in construction transportation. According to the Electrical Contractor, in 2017, 61 percent of all construction projects in the entire Netherland were shown to be behind schedule (Gavin, 2018). Further, of these delayed projects, more than half went over budget.

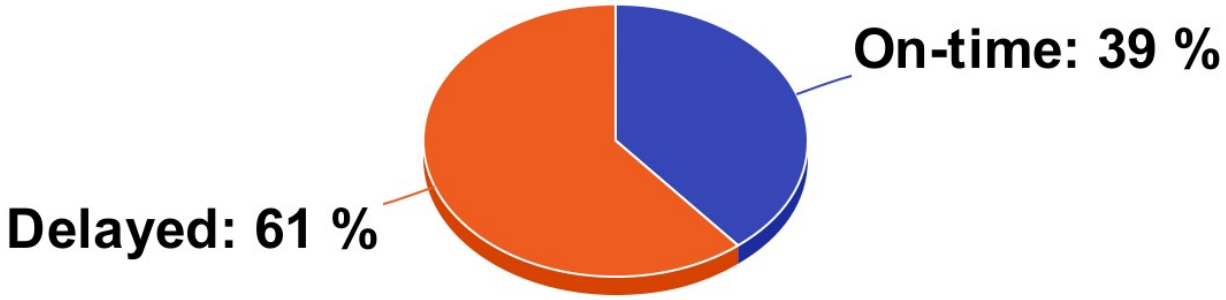

Figure 2: Time-scheduling of all construction projects in netherland in 2017

Hence, as proven, construction transportation delays are more common than they ought to be and they cause financial losses to companies. This only serves to reinforce the importance of transportation in the construction industry and proves that it is a key area that needs to be paid a lot more attention than it currently is.

Actually, transportation itself is a very wide terminology, covering many minute tasks. This is one of the reasons why it makes up such a huge component of the entire process of construction. Transportation includes procurement of raw materials, dispatch of vehicles to bring raw materials, loading and unloading of bulk materials into the vehicle, warehouse and

on-site, as well as dispatch of personnel to the site. Further, large-scale projects often require lab testing of the soil as well as raw materials which are being used which adds another component requiring transportation of samples collected from field to the lab.

Further, transportation requires multiple resources such as vehicles, fuel and personnel—for both driving and loading/unloading. The resource-dependent nature of this task also serves to make it all the more complicated. This complicated nature, in turn, leads to delays because of reasons like scheduling conflicts, lack of resources, etc. Further, there are also a lot of factors in the transportation process that have a tendency to cause delays but are outside the control of the people involved. For example, weather conditions, traffic jams, road closures, etc. All this serves to highlight the importance of planning and resource allocation in transportation.

3-Problem Statement

However, the above mentioned reasons are not good enough reasons to leave the construction industry be as it is. Its importance in the global market is far too great to be ignored. Therefore, it is imperative that new technologies are introduced in the industry that are latest and state-of-the-art in order to improve the various processes that make up the construction industry.

One such process is the transportation process and it happens to be a very crucial and vital step in the construction process. In fact, it would be correct to say that, in a way, the entire endeavor of construction a building or any other major infrastructure work depends wholly on transportation.

Transportation is needed at various stages in any construction project, no matter the size or scale of the project. First and foremost, raw material is needed to be transported to the site such as bricks, timber, and concrete, etc. usually from warehouses— and sometime directly from the vendor — to the site. Further, in large scale projects, transportation services are often needed within the site as well to get from one point to another and also to transport goods.

It is also important to note here that, often times, in these scenarios, transportation is not an ordinary feat that can be accomplished using everyday vehicles. For example, during transportation of concrete, special mixer trucks are used that constantly keep on mixing the concrete while it is on the road to avoid it setting and hardening prematurely.

All this serves to highlight what a crucial and imperative step transportation is in any construction project. Therefore, it is important that this step, in particular, is streamlined in order to avoid unnecessary delays and wastage of resources. Particularly, in the case of concrete, if the transportation is not done timely, it either sets prematurely or late. In both cases, it does not gain

enough strength and can ultimately lead to collapse of the structure.

This study deals with the proposal of Enterprise Resource Planning (ERP) in order to streamline and organize the process of transportation within the construction industry. ERP refers to the management of all key resources of a business, often within a single centralized system (Moon, 2007). This study aims to prove the effectiveness and usefulness of implementing ERP techniques in vehicle routing in order to minimize problems associated with transportation of 3D printed buildings.

4-Problem Solution

4.1-Enterprise Resource Planning to Improve Transportation

As mentioned in previous sections, ERP techniques can be implemented on all sorts of businesses across all sectors. Similarly, ERP techniques can be—and have been—implemented on transportation sector. This includes transportation sector independent of the construction industry as well as within the construction industry.

ERP techniques can be used to improve the process of transportation in all sorts of construction projects. It can allow for better resource allocation and remove scheduling conflicts.

Further, it can allow managers to plan ahead and do a better job of managing the entire process and completing projects on time.

ERP techniques, in this context, entail a centralized system that has records and log of all the resources typically need for transportation as well as their activity. For example, a manager would have access to the database detailing how many delivery trucks, drivers and movers are available at all times, on the site as well as in the company office. Further, he would also know how all details regarding past trips taken by the workers so he would be able to allocate work evenly between all personnel.

Moreover, if there is any fault in any delivery vehicle, that would also be logged into the system so the manager can assess the complete picture of available resources. Similarly, if some workers are not available for whatever reason—leaves, injuries, lunch breaks, etc.—that would also be logged into the system for the manager to see.

Additionally, an even more sophisticated ERP system would also find a way to integrate traffic and weather conditions into the system. This way, managers would be aware of realistic travel times so they will know when to expect the delivery vehicle and personnel to be back. Also, by looking at the traffic conditions, managers would be able to decide the most optimum route for the delivery vehicle that would save the most amount of fuel and time.

Another advantage of this system is that, when resources are dispatched to the site, the manager at the company headquarters can call ahead and let the site engineer know when to expect the delivery vehicle to arrive, based on the real-time traffic data he has access to. This way, when the vehicle arrives, the site engineer is prepared and the unloading is done in minimal time.

4.2-Methods of Integration of ERP Techniques

There exist multiple ways in which ERP techniques can be integrated into the process of vehicle routing and transportation in the construction industry. Each method will serve to make the process smoother and faster and minimize costs as well as time.

Firstly, as mentioned previously, managers should have a centralized program which keeps track of the inventory of raw materials needed for the project. These will, of course, change depending on the nature and scale of the project as well as the number of projects a company has going on at the same time. Any raw materials brought to the site or to the company warehouse—if it exists—must be logged into the centralized database. Further, the database should be programmed such that it informs the manager when inventory levels in the warehouse hit a certain minimum—say, 20%. That way, managers will have sufficient time to allocate funds and resources for transport of raw materials (Kennerly & Neely, 2001).

What this will serve to do is avoid excessive buildup of raw material at the site (where they can get damaged from weather elements) or in the company warehouse which will use up the funds and resources needed for transport. Further, since managers will know beforehand that inventory needs to be ordered, they will be able to easily allocate vehicles, personnel and fuel to bring the inventory. Additionally, this is also a step that can indirectly lead to an increase in employee satisfaction since no employees will have to make last minute trips to transport inventory. This has been proven in previous studies also that better management skills have a direct positive correlation with employee satisfaction and performance (Karimi, 2017).

Similarly, progress should be monitored by site engineers on site where the actual construction is being carried out. They should keep track of quantities of all required raw materials they have and anticipate when they will require new ones. When these levels also hit a specified low, they should call the manager in the company office and let them know. Once again, this will serve as a means to avoid last minute resource allocation for transportation.

Additionally, arguably the biggest advantage of implementing ERP techniques is that all required information is available for managers to see in a centralized management system (Voordijk, Leuven, & Laan, 2003). When they have the complete picture available of all scenarios, it enables them to make better and

more efficient decisions. In the current context, ERP techniques can enable managers to devise routes for transportation (of both raw material and building components) that save both time and fuel, thus helping the company. Such techniques have been adopted by other companies in the past and have proven to be a huge success (Jayarathna, Lanel, & Juman, 2022).

Moreover, as previously mentioned, implementation of ERP techniques enables managers to see the complete picture as they have all required information at hand. Because of this, they can observe in real time wherever there are lags or delays in the transportation process. This will enable them to carry out continuous improvement and achieve maximum efficiency. Many researchers have also pointed out that ERP techniques enable managers to carry out effective project management (Zhang, Lee, Zhang, & Banerjee, 2002). Some studies have also pointed especially at the importance and effectiveness of using ERP techniques to make real-time changes to delivery routes (Giaglis, Minis, Tatarakis, & Zeimpekis, 2004).

In this way, ERP techniques can be adopted into the 3D printing industry and they can serve to improve the transportation process and maximize the efficiency of transportation.

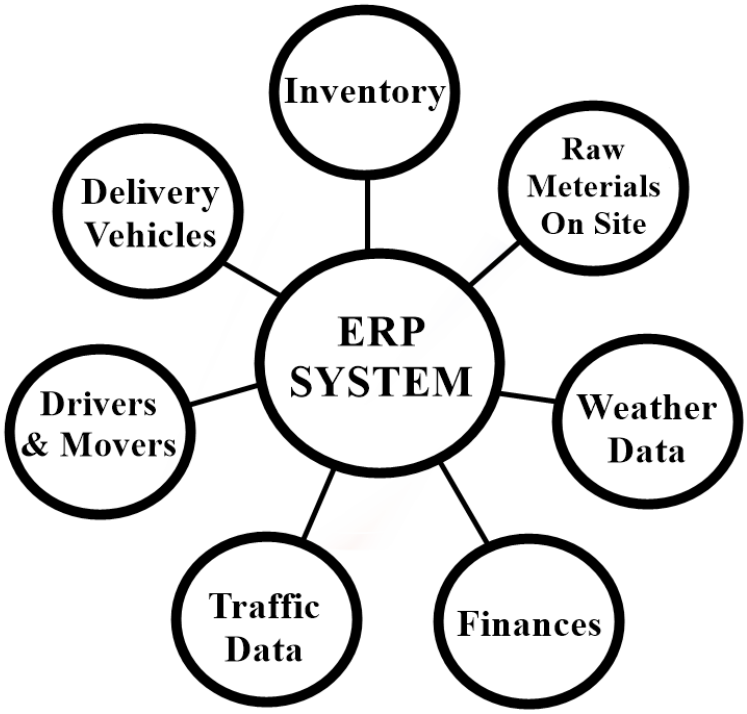

Figure 3: Key Components of an ERP system for transportation of 3D printed buildings

4.3-Advantages of Integration of ERP Techniques

Implementation of ERP techniques in transportation serves numerous benefits to all stakeholders in the production process (Aziz, Ragheb, Ragab, & Mokadem, 2018). Arguably, the biggest advantage that it serves is that it enables the production and assembly processes to run smoothly without any stops or interruptions. This, in turn, increases the efficiency and productivity of the entire construction process. Consequently, profits are boosted and client satisfaction is achieved.

Further, ERP techniques can be used to avoid cash flow problems in the organization. Managers will have access to real time inventory data so they will only order inventory when needed. This will help to avoid over-ordering of inventory as transportation resources will only be allocated when needed. Subsequently, funds will not be tied up in unnecessary buying and storing of raw material for 3D printer ink. There exist multiple studies that have examined in-depth the relation between ERP systems and liquidity of businesses and found a positive correlation between the two (Matolcsya, Booth, & Wieder, 2005). Transportation costs will also decrease to a bare minimum as number of trips of vehicles will be as few as possible.

Additionally, this will also allow the site work—i.e. the actual construction of the project—to be carried out in an uninterrupted fashion by ensuring a continuous supply of raw materials. This will, once again, result in a reduction of time and costs and maximization of profits.

Also, another advantage would be that overhead costs can be minimized due to immediate transportation. As soon as raw material are needed, they can be bought directly from the vendor and transported on site to be used, rather than storing them in a warehouse. This would reduce overhead costs of storage to be borne by the firm and thereby maximize the profit margin.

In this way, implementation of ERP techniques can serve various benefits for firms as well as employees.

5-Future Work

3D printed buildings are all the rage in the construction industry as the latest trend. They are a cheaper and faster alternate to traditionally constructed buildings (Han, Yang, Ding, & Xiao, 2021). In recent years, as climate change and global warming have become pressing concerns, 3D printed buildings have gained a lot of traction as they are far more sustainable and eco-friendly than their traditional counterparts. Further, with the advent of newer and faster 3D printers, this technology has become much more reliable and accessible than it was in the past.

When 3D printing entire buildings and houses, engineers typically have two options. They can either opt for a movable printer which they can transport on site and then 3D print the buildings on-site, according to the plan and designs. However, this often proves to be extremely expensive, owing to the cost of the movable 3D printers. Further, this requires multiple very skilled and experiences engineers to be available on site to supervise the 3D printers. Hence, this proves to be extremely expensive as unskilled laborers are replaced with skilled engineers who are to be paid more.

The second option that engineers have is to 3D print components of buildings—i.e. walls, roof, stairs, etc.—and then transport these to the site. Once these have reached the site, they are assembled with the help of cranes according to the structural

drawings of the buildings. In this way, buildings are mass produced and assembled, thereby drastically bringing down the cost and time typically associated with traditional construction methods. This method, albeit new, has proven to be more feasible as less engineers are required on-site, thereby bringing down the costs. Further, due to mass production, time and costs are further decreased.

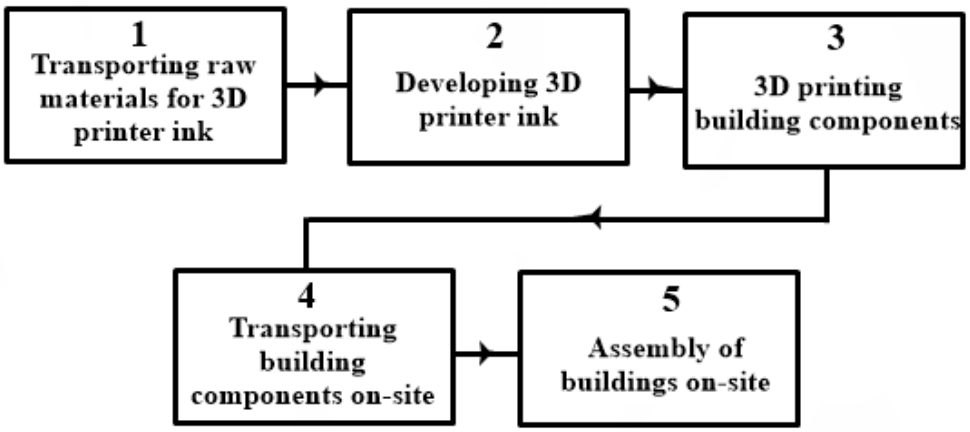

Figure 4: Schematic diagram of process of 3D printing buildings

The entire process outlined in the previous section is has multiple stages, all depending on one another. In such cases, if one stage or step of the process is disrupted, it ends up disturbing the entire process and production grinds to a halt. This can lead to massive losses and reduction in profits and, hence, must be avoided at all costs.

On a similar note, transportation is a very important aspect of this entire multi-step process. Some might even argue that it is the most important facet of this production process, because it is

involved in multiple stages. Firstly, raw material for developing the ink in the 3D printers has to be transported from its point of origin to the factories. Secondly, the 3D printed components have to be transported from the production factory to the site where they will then be assembled.

All this transportation requires resources such as vehicles, personnel and fuel. There might even be additional costs associated with vehicle maintenance in some instances. Hence, it is important that all aforementioned resources are properly and timely allocated to avoid any unforeseen delays in the production process.

For this purpose, enterprise resource planning (ERP) techniques can prove to be especially helpful. As has been established in the previous sections of this study, construction industry as a whole can stand to gain numerous benefits from implementation of ERP systems.

More specifically, 3D printed building businesses are quite possibly the most suitable candidates for ERP systems out of all the different types of construction firms. This is because transportation makes up such a huge portion of their production process. Hence, they can gain more benefits from ERP systems as compared to any ordinary or conventional construction firm. It is imperative for such type of businesses to integrate ERP systems within the framework of their organization to ensure maximum efficiency.

6-Recommendations

From the previous discussion, it can be concluded that construction industry—and, more specifically, 3D printing building businesses— stand to gain enormous benefits from integrating an ERP system into their business model. This study proves through its in-depth analysis that ERP systems can help construction companies—and particularly those that deal with manufacturing of 3D printing buildings—maximize their profits and minimize their costs, provided that they are installed and implemented correctly.

A tentative framework for the ERP system in this context has also been suggested. Some key areas that the ERP should focus on have also been suggested and their benefits have been explained. These key areas are:

1. Inventory
2. Delivery Vehicle
3. Drivers + Loaders
4. Printed Building Components
5. Traffic Conditions
6. Weather Data
7. Finances

However, the most important thing to note here is that simply installing or implementing an ERP system does not automatically guarantee success. It is imperative that managers ensure the

smooth onboarding of all employees to the ERP system and deliver extensive training to familiarize them with this new framework.

3D printing of buildings itself is a relatively new industry that is still trying to gain a foothold in the construction market. An ERP system will definitely help to make 3D printing businesses more successful but special care must be taken by managers during the implementation process. They must ensure the comfort of all stakeholders involved in order for the ERP system to be successful.

7-Conclusion

This study deals with the implementation of ERP techniques for solving vehicle routing problems in the construction industry. Existing case studies of implementation of ERP within construction firms have been discussed in order to glean an understanding of what factors are imperative for the success of an ERP system. A tentative framework for ERP system in the context of transportation in a construction firm has been developed. Various methods have been suggested through which this ERP system can be integrated into the transportation processes of construction firms.

Furthermore, advantages and benefits of implementing these methods have been clearly outlined. Evidence and previous research is presented which confirms that ERP implementation

can have many benefits in this context. It can streamline the production process, increase efficiency and profits and decrease costs as well as waste.

Moreover, an important suggestion has been made that ERP systems should, in particular, be implemented for mass transportation of 3D printed building components. This important recommendation has been highlighted because, as of yet, 3D printing is still relatively niche and mainly only popular in developed countries. However, as it becomes more and more mainstream and popular, implementing ERP techniques would make this process more efficient and profitable for all stakeholders.

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